

1 WHAT IS CLAIMED IS:

5 1. A method for forming a stratum consisting of semiconductor particles, comprising the steps of:

a) forming an original plurality of discrete semiconductor particles from one of a source of semiconductor material and a precursor for said semiconductor material, said original plurality of discrete semiconductor particles entrained in a gas and thereby forming an aerosol;

10 b) heating said aerosol to a sufficiently high temperature to densify said particles such that substantially all of said particles include a density substantially as great as the bulk density of said semiconductor material and thereby forming a corresponding plurality of densified discrete semiconductor particles entrained in a gas;

15 c) forming an electrically insulating cover on each of said particles, thereby forming a corresponding plurality of insulator-coated densified discrete semiconductor particles; and

d) depositing said plurality of insulator-coated densified discrete semiconductor particles on a substrate thereby forming a stratum of discrete, electrically isolated semiconductor particles on said substrate.

20 2. The method as in claim 1, in which step a) includes pyrolyzing a gas.

25 3. The method as in claim 2, in which step a) includes said pyrolyzing occurring during a ramp-up period ranging from 10-50 msec, during which said gas is heated to a maximum temperature.

4. The method as in claim 3, in which said maximum temperature lies within the range of 950°C to 1150°C.

30 5. The method as in claim 3, in which said gas flows through a pyrolysis furnace at a flow rate ranging from 650 to 850 sccm during said ramp-up period.

35 6. The method as in claim 3, in which step a) includes intermixing said gas with a diluent gas prior to said gas attaining said maximum temperature.

1 7. The method as in claim 3, further comprising maintaining said gas at said maximum temperature during said step of heating for a time ranging from 200 msec to 600 msec.

5 8. The method as in claim 1, in which said step b) includes said heating converting a majority of said original plurality of discrete semiconductor particles to single crystalline material, said heating occurring at a sintering temperature within the range of 950°C to 1150°C.

10 9. The method as in claim 8, in which step a) includes pyrolyzing a gas during a ramp-up period ranging from 10-50 msec, during which said gas is heated to said sintering temperature and intermixed with a diluent gas to form a gas mixture, and said step b) includes said gas mixture having a flow rate ranging from 1300 sccm to 1700 sccm.

15 10. The method as in claim 1, in which step c) comprises thermal oxidation and said cover comprises an oxide cover.

20 11. The method as in claim 1, in which step c) comprises chemical vapor deposition.

25 12. The method as in claim 1, in which step c) includes reacting surfaces of said particles with a gas.

30 13. The method as in claim 1, in which step c) comprises depositing silicon dioxide on said semiconductor particles using TEOS (tetraethyl orthosilicate).

35 14. The method as in claim 13, in which said depositing silicon dioxide using TEOS takes place at a temperature no greater than 750°C.

 15. The method as in claim 1, in which said original plurality of discrete semiconductor particles comprise silicon particles and said insulator-coated densified discrete semiconductor particles each include a silicon core and a silicon dioxide shell.

1 16. The method as in claim 2, in which said step a) includes delivering said
gas to a pyrolysis furnace in the form of a gas stream, said gas stream including a
mixture of a carrier gas having a flow rate within the range of 650 sccm to 850 sccm,
5 and silane gas and including about 5000 ppm of silane in nitrogen and having a flow
rate less than 1 sccm.

10 17. The method as in claim 2, in which said gas includes silane and a carrier
species, and said step a) includes delivering said gas and a diluent gas to a pyrolysis
furnace.

15 18. The method as in claim 17, in which said diluent gas comprises nitrogen.

20 19. The method as in claim 17, in which said gas is delivered within a tube
axially disposed within a further tube, said diluent gas is delivered within said further
tube, and said gas and said diluent gas are allowed to intermix within said pyrolysis
furnace.

25 20. The method as in claim 1, further comprising the step of classifying
particles of said plurality of densified discrete semiconductor particles after step b), and
directing a classified plurality of densified discrete semiconductor particles within a pre-
selected range of sizes for further processing.

30 21. The method as in claim 20, in which said pre-selected range of sizes
includes particles having average diameters within the range of 5-10 nm.

35 22. The method as in claim 20, in which said step of classifying includes
applying an electric field to a differential mobility analyzer.

 23. The method as in claim 20, in which said step of classifying includes time-
of-flight separation of a focused particle beam.

 24. The method as in claim 20, further comprising cooling said discrete
semiconductor particles after said step of heating and prior to said step of classifying.

1 25. The method as in claim 1, in which step d) comprises delivering said
plurality of insulator-coated densified discrete semiconductor particles to a deposition
5 chamber including said substrate therein, and thermophoretically depositing said
plurality of insulator-coated densified discrete semiconductor particles on said
substrate.

10 26. The method as in claim 25, in which step d) includes maintaining said
substrate at a temperature which is at least 175°C cooler than internal portions of said
deposition chamber.

15 27. The method as in claim 1, in which step d) includes thermophoretically
depositing said stratum to include a density of 10^{12} - 10^{13} particles/cm².

20 28. The method as in claim 1, in which step d) produces said stratum which
is characterized by a foreign contamination level being less than 10^{11} atoms/cm².

25 29. The method as in claim 1, in which said substrate includes a dielectric
layer formed thereon and said step d) comprises depositing said insulator-coated
densified discrete semiconductor particles on said dielectric layer, thereby forming said
stratum over said dielectric layer.

30 30. The method as in claim 29, in which said dielectric layer comprises a
tunnel oxide and further comprising the steps of:
 forming a gate dielectric film over said stratum;
 forming a gate electrode over said gate dielectric film; and
 defining a gate region and removing portions of said gate electrode, said gate
dielectric film, said stratum, and said tunnel oxide from regions outside of said gate
region.

35 31. The method as in claim 30, in which said tunnel oxide includes a thickness
within the range of 3 to 12 nanometers.

 32. The method as in claim 1, in which step d) includes said stratum being
essentially a monolayer of said oxidized semiconductor particles.

1 33. The method as in claim 1, in which step d) includes:
introducing said plurality of insulator-coated densified discrete semiconductor
particles into a liquid medium to form a colloid; and
5 electrophoretically depositing said plurality of insulator-coated densified discrete
semiconductor particles onto a surface of said substrate.

10 34. The method as in claim 1, in which step d) includes:
delivering said plurality of insulator-coated densified discrete semiconductor
particles to a deposition chamber which includes said substrate therein; and
forming an ordered structure of said plurality of insulator-coated densified
discrete semiconductor particles on said substrate, using contact mode atomic force
microscopy.

15 35. The method as in claim 34, in which said step d) comprises forming a wire
of said insulator-coated densified discrete semiconductor particles.

20 36. A method for forming a stratum of a plurality of discrete nanoparticles,
comprising the steps of:

- 25 a) decomposing a material to produce an original plurality of discrete metal
nanoparticles entrained in a gas and thereby forming an aerosol;
b) classifying particles of said original plurality of discrete metal nanoparticles
by size, and delivering a classified plurality of discrete metal nanoparticles within a pre-
selected range of sizes for further processing;
c) forming an electrically insulating cover on each of said particles thereby
forming a corresponding plurality of insulator-covered nanoparticles;
d) delivering said plurality of insulator-covered nanoparticles to a deposition
chamber which includes a substrate therein; and
e) thermophoretically depositing said plurality of insulator-covered
30 nanoparticles on said substrate thereby forming a stratum of discrete insulator-covered
nanoparticles on said substrate.

35 37. The method as in claim 36, in which step a) comprises spark ablation.

38. The method as in claim 36, in which step a) comprises laser ablation.

1 39. The method as in claim 36, in which step a) comprises gas evaporation.

40. A method for forming a stratum consisting of semiconductor particles, comprising the steps of:

5 pyrolyzing a particle source gas to produce an original plurality of discrete semiconductor particles;

quenching said particle source gas with a diluent gas during said step of pyrolyzing;

10 classifying particles of said original plurality of discrete semiconductor nanoparticles by size and directing a classified plurality of said discrete semiconductor particles to a deposition chamber which includes a substrate therein; and

thermophoretically depositing said classified plurality of said discrete semiconductor particles on said substrate thereby forming a discontinuous layer of said discrete semiconductor particles on said substrate.

15 41. The method as in claim 40, further comprising the step of sintering said original plurality of discrete semiconductor particles to form a corresponding plurality of crystalline semiconductor particles.

20 42. The method as in claim 1, wherein said step c) comprises encapsulating said particles.

25 43. The method as in claim 1, in which step a) includes forming said original plurality of discrete semiconductor particles to have diameters less than 20 nanometers.

44. A method for forming a stratum consisting of metal particles, comprising the steps of:

30 forming an original plurality of discrete metal particles from one of a source of metal material or a precursor for said metal material, said original plurality of discrete metal particles entrained in a gas and thereby forming an aerosol;

35 heating said aerosol to a sufficiently high temperature to densify said particles such that substantially all of said particles include a density substantially as great as a bulk density of said metal material and thereby forming a corresponding plurality of densified discrete metal particles entrained in a gas;

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forming an electrically insulating cover on each of said particles, thereby forming a corresponding plurality of insulator-coated densified discrete metal particles; and

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depositing said plurality of insulator-coated densified discrete metal particles on a substrate thereby forming a stratum of discrete, electrically isolated metal particles on said substrate.

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